Superconducting Magnet Division
Magnet Division Specification

Proc. No.: LHC-MAG-R-1052

Issue Date: April 12, 2002

Rev. No.: B

Rev. Date: May 27, 2003

Title: LHC D1/D2/D3/D4 Warm and Cold Integral Testing

Prepared by: Signature on File

Cognizant Engineer: Signature on File

Section Head: Signature on File

Q. A. Approval: Signature on File

ES&H Review: Signature on File

REVISION RECORD

Rev. No.	Date	Subject	Approval
A	4/12/02	Initial Release	
B	5/27/03	Changes per ECN MG2145.	

1 Scope:

This procedure describes the methods used to perform warm and cold integral testing of LHC D1/D2/D3/D4 magnet assemblies. Warm and Cold tests are performed separately or together as a part of magnet acceptance procedures. They are also performed as an "in-process" test to ensure the quality of a magnet assembly prior to completion.

2 Applicable Documents:

RHIC-MAG-Q-1004 Discrepancy Reporting Procedure

3 Requirements:

3.1 Material/Equipment:

See procedure.

3.2 Safety Precautions:

3.2.1 Ensure magnetic field strengths have been measured or calculated and the required postings are in place as per the Static Magnetic Field SBMS Subject Area: https://sbms.bnl.gov/standard/1u/1u00t011.htm

3.3 Warm Integral Coil Measurement Runs

3.3.1 Instruments and Devices Required:

- Integral Coil
- Integral Coil Insertion and Rotation Tool for moving the integral coil into the magnet
- PC with HTBasic and IEEE488 card
- Six HP Digital Multimeters (6 HP3458A's)
- D/Q Dual Mode (QCD) Warm Power Supply

3.3.2 Cable Connections

	Address	Meter	Input	Trig
1	725	3458A	Coil 1	Ext¶
2	726	3458A	Coil 2	Ext
3	727	3458A	DCCT 1	Ext
4	728	3458A	DCCT 1	Ext
5	729	3458A	Coil 1	Ext
6	730	3458A	Coil 2	Ext

¶All external triggers come from the IOtech 488HR in the D/Q WPS rack.

Note

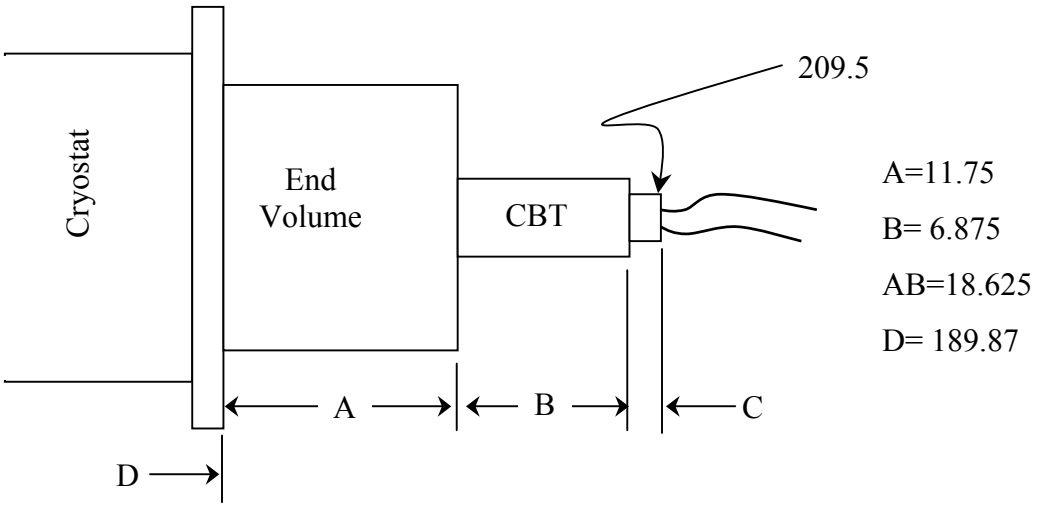
There are only three signals and each signal is T'd so that each one goes to two meters.

If the PC is one contained in a cart, it is important to avoid potential address conflicts between any devices in the cart and the other devices (the HP 3458A DMMs). Either disconnect the IEEE 488 cable connections between the computer and the devices in the cart that are not being used, or make certain that none of the DVM addresses conflict.

3.3.3 Setup

3.3.3.1 Turn on HP 3458A DVMs 4 hrs. before starting.

3.3.3.2 Place the integral coil in the middle of the magnet and at the nominal rotation angle as per standard test procedures. See figure below.



NOTE

Middle of magnet cryostat (from end flange "D") is also the location of magnet cold mass middle.

3.3.3.3 Connect the D/Q power supply cable to the connectors using the same hook-up as for warm measurements.

3.3.3.4 Turn on the D/Q Warm Power Supply

3.3.3.5 Log into the network.

3.3.3.6 At the DOS prompt, enter "HTB". Then get and run the file "INTCOIL.W5T".

3.3.3.7 Enter Test as the run number (the entry is not case sensitive).

3.3.3.8 If *Npass* ≠ 1, set *Npass* to 1.

3.3.3.9 Observe the resistance readings for each of the two coils, the values should be 2380 ohms ± 50 ohms (each BNC - Fixed Integral Coil).

NOTE

This resistance will vary with temperature

3.3.3.10 Toggle Plot to "yes" if necessary — "yes" is the default

3.3.3.11 Take a test read by pressing the *Ramp:1* key, the plot should look something like the one attached.

3.3.3.12 Observe the two boxed quantities (C1 & C2) in the upper right corner of the plot. The numbers should be about equal in magnitude (~0.29) but opposite in sign. If they are not, then it is necessary to rotate the coil form until they are.

NOTE

Two runs are to be performed:

In the first run, measurements are taken at a single rotation position where C1 ≈ -0.29 and C2 ≈ + 0.29.

In the second run, the coil form is rotated until one signal (C1) is 0.000 ± 0.005 V. Readings are taken and then the coil form is rotated so that the signal is -0.030 ± 0.005 V. This process continues until the voltage on the observed coil is ~ - 0.300 ± 0.005 V (that is, about the same as the voltage on the other coil (C2), which has been decreasing as the coil form was rotated). Then the *other* coil is monitored and the coil form is rotated to reduce its voltage to 0.000 V in 0.030 V steps.

3.3.4 Performing the First Run

3.3.4.1 Restart the program. Enter an actual Run Number using the standard style.

3.3.4.2 To prepare for the set of measurements, press the *Adj. Coil* key. Observe the line printed out that gives the values for the average voltages on Coils 1 and 2. If C1 ≠ -0.29 ± 0.009, rotate the coil form, press the *Adj. Coil* key again to acquire a new reading, and observe the new values reported for the average voltages on the coils. Next, if the magnitudes of the voltages on C1 and C2 (ignore the sign of the voltage) are not equal to within ± 0.005 V, rotate the coil form until this condition is satisfied.

3.3.4.3 Mark the Integral Coil Insertion and Rotation Tool for this angular position.

3.3.4.4 If *Npass* ≠ 20, use the *Npass* key and set *Npass* to 20.

3.3.4.5 Toggle Hard Copy to "yes".

3.3.4.6 Take two (2) sets of 20 measurements. Each press of the *Ramp:1* key provides one set of measurements.

Steps 3.3.4.7 and 3.3.4.8 are optional. Do the following two steps only if requested to do so.

3.3.4.7 Move the coil longitudinally, inserting it two (2) additional inches into the magnet. Verify that C1 and C2 have the same magnitude to within ± 0.005. Set *Npass* = 10. Take two (2) sets of 10 measurements.

3.3.4.8 Move the coil out longitudinally four (4) inches, so that it is two (2) inches *farther out* of the magnet than it was when it was centered. Verify that C1 and C2 have the same magnitude to within ± 0.005. Set *Npass* = 10. Take two (2) sets of 10 measurements.

End of Optional steps.

3.3.4.9 Transfer the data using the Network key.

3.3.4.10 Exit the program.

3.3.4.11 Return the coil form to its centered position.

3.3.5 Performing the Second Run

3.3.5.1 Restart the program. Enter an actual Run Number using the standard style.

3.3.5.2 To prepare for the set of measurements, press the *Adj. Coil* key. Observe the line printed out that gives the values for the average voltages on Coils 1 and 2. If ABS(C1) ≠ 0.000 ± 0.005, rotate the coil form, press the *Adj. Coil* key again to acquire a new reading, and observe the new values reported for the average voltages on the coils. Repeat the process of rotating the coil form and pressing the *Adj. Coil* key until ABS(C1) = 0.000 ± 0.005.

3.3.5.3 Mark the Integral Coil Insertion and Rotation Tool for this angular position.

3.3.5.4 If *Npass* ≠ 5, use the *Npass* key and set *Npass* to 5.

3.3.5.5 Toggle Hard Copy to “yes”.

3.3.5.6 Take one (1) set of 5 measurements by pressing of the *Ramp:1* key once.

3.3.5.7 Rotate the coil form so that the signal [- (C1)] is 0.030 ± 0.005 V by first turning the coil form a small amount, then pressing the *Adj. Coil* key to see what the voltages are and repeating this process until the voltage has the desired magnitude. Be sure to mark on the coil form which way you are rotating it relative to the position in the preceding step so that you can continue to move in this direction when you go on to the next position. As getting to within ±0.005 V at each position is a trial and error procedure and thus may require rotating the coil form first one way and then the other, it is easy to get confused about the general direction you are going as you move from one measurement position to the next. Once you have obtained the proper position as indicated by the voltages reported by pressing the *Adj. Coil* key, you are ready to take the measurements at this position. To do so, press the *Ramp:1* key once. (*Npass* remains at the value 5 for all the measurement positions).

3.3.5.8 Rotate the coil form (continuing in the same direction) until the magnitude of the voltage on Coil 1 is 0.060 ± 0.005 using the same procedure as in the step above. Once the position has been reached, press the *Ramp:1* key once.

3.3.5.9 Continue on in this way for positions where the magnitude of the voltage on Coil 1 is -0.090, -0.120, -0.150, -0.180, -0.210, -0.240, -0.270, and -0.300 V.

3.3.5.10 Now shift your attention to the voltages on Coil 2. The magnitudes of these voltages have been decreasing as the magnitudes of the voltages on Coil 1 increased. Rotate the coil form (still continuing in the same rotation direction) until the voltage on Coil 2 is 0.270 ± 0.005 V. Once this position has been obtained (again using the *Adj. Coil* key to measure the voltages on the coils and thus find the position), press the *Ramp:1* key once to take the five measurements at this position.

3.3.5.11 Continue on in this way for positions where the magnitude of the voltage on Coil 2 is +0.240, +0.210, +0.180, +0.150, +0.120, +0.090., +0.060, +0.030, and 0.000 V.

3.3.5.12 Transfer the data using the Network key. Exit the program.

3.4 Cold Integral Coil Measurement Runs

3.4.1 Instruments and Devices Required:

- Integral Coil
- Long Integral Coil Insertion and Rotation Tool for moving the integral coil into the magnet
- PC with HTBasic and IEEE488 card in Horizontal Control Room
- Three HP Digital Multimeters (3 HP3458A's)
- IOtech DAC 488/HR

3.4.2 Cable Connections

DVMs

	Address	Meter	Input	Trig
1	727	3458A	MPS DCCT	Ext¶
2	728	3458A	Coil 1	Ext
3	729	3458A	Coil 2	Ext

¶All external triggers come from the IOtech 488HR, Port 1.
NOTE: Do NOT use the IOtech 488HR Trigger Out BNC.

IOtech 488HR

Connect the trigger cable for the DVMs to Port 1.
Connect the) -MPS cable to Port 2.

MPS

At one point in the procedure, you will need to connect the other end of the) -MPS cable to a card in the MPS control racks, and to flip a switch on that card from **I**nternal to **X**ternal.

The meters and IOtech 488HR should be connected through the fiber optic extension of the HP-IB bus that is normally used to connect to the transporter controller. It is probably advisable to disconnect the instruments in the vertical rack that is used for the mole runs in order to avoid address conflicts.

There will be more than three HP 3458A DVMs in the rack. Disconnect the HP-IB cable going from the third DVM to the ones below it so you don't have to worry about their address settings. Use the short HP-IB cable to connect the IOtech 488HR to one of the three DVMs below. Connect a HP-IB cable between the fiber optic HP-IP Extender and the instruments in the rack.

NOTE

Do not try to eliminate an address conflict by turning off the unused meters. Rather, change their addresses or disconnect the HP-IB cable.

In addition to the HP-IB cable (IEEE488) that connects all the meters, there is also a trigger cable. All the meters are connected in parallel at their Ext. Trig BNCs to the trigger cable. If one or more of the meters below are turned off, the trigger signal will be loaded down and the meters in use may not be triggered. (Actually, this problem with triggers has only been observed when the trigger signal came from one of the Buckets for the rotating coils rather than from a DAC, but it's a good idea to leave the meters "on" in any case so they will be warmed up and ready for any subsequent measurements that may need them.)

3.4.3 Setup

3.4.3.1 Turn on HP 3458A DVMs 4 hrs. before starting.

3.4.3.2 Place the integral coil in the middle of the magnet and at the nominal rotation angle as explained in this paragraph. The integral coil is 410.125" long. There is a mark on the integral coil insertion and rotation tool that indicates how far in to push the integral coil. Also, on the tip of the tool (at the operator's end, not the coil end), is a short line. This line should be placed at the top to properly orient the integral coil inside the magnet.

3.4.3.3 Connect all the equipment cables.

3.4.3.4 Turn on the MPS and bring it to 50 A.

3.4.3.5 Log into the network.

3.4.3.6 At the DOS prompt, enter "HTB". Then get and run the file "INTCOLD.C3".

3.4.3.7 Answer the question about whether the Time as reported by the computer clock is correct.

3.4.3.8 Enter the magnet name, then the Run Number using the standard style.

3.4.3.9 Tell the program that the ramp rate (also known as $\dot{I}$, Idot, or Irate) will be 20 A/s, I_{end} will be 5900 A, and I_{start} will be 50 A, when asked.

3.4.3.10 Adjust the coil position. Set up the meters for taking the readings for adjusting the coil position by pressing the *Adjust Coil* button and then answering "Y" (default) to the question about whether this is a manual adjustment. The "manual" choice will result in the program simply configuring the meters appropriately to see the voltages, but won't cause data to be stored or moved about.

3.4.3.11 Enter the command to ramp the MPS from 50 A to 5900 A and then back to 50 A at 60 A/s. Immediately after you press *Return* to start the ramping, go out to the magnet where the integral coil is located. Observe the voltage readings. They should be about equal (±0.005 volts), and have opposite sign. If they aren't, use the coil insertion and rotation tool to rotate the coil. If you don't succeed in getting the proper orientation during the first ramp, go back to the control room, start another up and down ramp, and try again.

3.4.3.12 As soon as you have the voltages about equal, go to the MPS racks. Observe the reading on the HP 3456A there and, if the MPS is still ramping, wait until the current is stable at 50 A. (Expect a reading of about 0.0499 V on the HP 3456A.) Then remove the cover for the) I controller for the ramps, plug in the) I cable, and flip the switch from **I** to **X** (for externally controlled). After you have flipped the switch, you can request the MPS to ramp, but no) I current changes will occur unless pulses are received from the IOtech 488HR. However, you must not enter the commands too early either, since the IOtech488HR over-pulses in order to insure that the desired end current is reached. If the command for the down ramp is entered while the IOtech488HR is over pulsing at the flat top, the MPS will begin ramping down but won't receive enough pulses to complete the down ramp. Now that everything is done from the control room, coordinating the data acquisition and MPS control is simple. (See steps below.)

NOTE

Six runs are to be performed.

Run	I at Start	I at End	Ramp Rate
1	50 A	5900 A	20 A/s
2	5900 A	50 A	20 A/s
3	50 A	5900 A	40 A/s
4	5900 A	50 A	40 A/s
5	50 A	5900 A	60 A/s
6	5900 A	50 A	60 A/s

Note that Run 2 is the down-ramp of Run 1, Run 4 is the down-ramp of Run 3, etc.

3.4.4 Performing the Runs

NOTE

The program is not run four times as you might expect. The program creates a file with the Run Number that is the same as that for the first run, then creates four (or as many as needed) data files which are later analyzed and used to create four ASCII files that have the expected names. The ASCII files are then transferred to the network. The file on the PC with the Run Number is not a critical file, since it has little information in it except at what number to begin naming the analyzed data files. Don't worry if you have to restart the program and somehow overwrite or purge this file. The program will automatically avoid overwriting any actual data files no matter how many times the program is restarted.

3.4.4.1 If Idot is not correct for the ramp to be measured, press the *Change Idot* button and set it correctly. You will also be asked whether the beginning current has been changed. Since we no longer do measurements at different beginning currents, you may always just press Enter.

3.4.4.2 Press the *Enable Ramp* button.

3.4.4.3 **Wait for the PC to display that it is Ready to generate the ramp.** (This means that it is ready to send the) I pulses to generate enough) I steps to take the current from its present value to the desired end value. It will also generate enough DVM triggers before starting the ramp and at the end to get flat regions both before and after.).

3.4.4.4 Enter the appropriate ramp command at the micro-VAX workstation. If the PC is displaying that it is ready to generate the ramp, then press the Return key on the micro-VAX keyboard. **Wait for the PS Status display to show "Holding."**

3.4.4.5 Press the Continue key on the PC computer keyboard. After a slight delay to record a flat region, the current should start ramping. If nothing appears to happen, you may have pressed the Enter key by mistake. No harm was done if you did, so go ahead and press the Continue key. The PC display will show the expected time for the ramp and how much of that time has expired. When the two times are about equal, it will begin transferring the data points stored in the three HP DVM's across the HP-IB bus and into the computer's RAM memory. It will then plot the data on the screen.

3.4.4.6 Unless there is something clearly wrong with the data, press Enter in order to input the default response of "Y" to the question as to whether you wish to store the data. The data will then be stored on the hard disc. (The "active" light for the PC hard disc will flash.) If the data do not look right, you will need to figure out what is wrong or to get help.

3.4.4.7 After some analysis of the data, the computer will ask whether you want to print out the results for the ramp. The default answer is "N", which is the desired answer, so just press Enter.

3.4.4.8 Repeat steps 3.4.4.3 through 3.4.4.6 for the "Down" ramp. (You don't have to press the *Enable Ramp* button this time, since the program assumes that what goes Up must come Down.).

3.4.4.9 Repeat steps 3.4.4.1 through 3.4.4.8 for the "Up" and "Down" ramps at 80 A/s.

3.4.4.10 Press the *Network* button. The program will count the number of data files created and then suggest the run numbers to reserve for these runs.

3.4.4.11 The program "d:\intcoil\Plt.BLI" will then be automatically loaded and started. You will be asked whether you want a hard copy of the plots and whether to create the data transfer files. Answer "Y" to the second question.

3.4.4.12 Respond to the program's prompts, either confirming the Magnet name and first run number or entering new values.

3.4.4.13 Plt.BLI will now automatically read each of the data files created, plot the raw data (I_m, V_{c1}, and V_{c2}), and analyze it (including computing BLI and plotting it). An ASCII *.dat file will be created for each run automatically. After each analysis, the *.dat file and the raw data files will be copied from the PC to the network file server by the program. You may continue with the following steps while the program performs these operations.

3.4.4.14 Go out to the MPS and remove the) -MPS cable from the card. Stick it under the handle where you got it so it will be easy to find next time. Then flip the switch from **X** to **I**, and replace the cover.

3.4.4.15 Ramp down the MPS and turn it off.

3.4.4.16 Remove the integral coil.

3.4.4.17 Return the HP-IB Fiber Optic Extender to the Transporter Controller and hook the cables back up both there and in the vertical rack used for the instruments for the mole measurements at the horizontal bays.

3.4.4.18 Return the DVMs to a storage location and leave them plugged in and turned on.

4 Quality Assurance Provisions

4.1 The Quality Assurance provisions of this procedure require that the technician shall be responsible for performing all operations in compliance with the procedural instructions contained herein and the recording of the results on the production traveler.

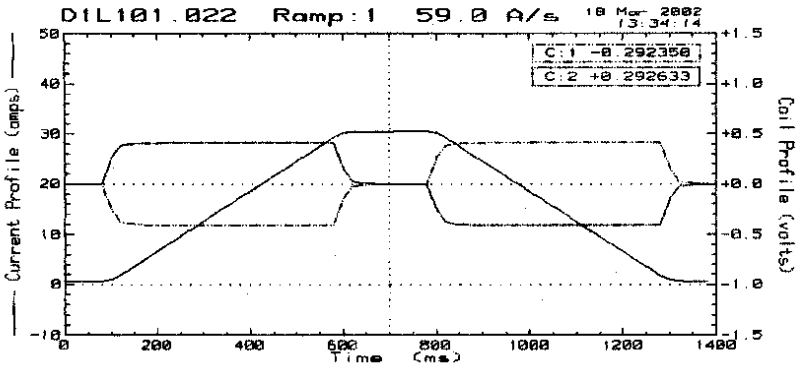
4.2 The technician is responsible for notifying the technical supervisor and/or the cognizant engineer of any discrepancies occurring during the performance of this procedure. All discrepancies shall be identified and reported in accordance with RHIC- MAG-Q-1004.

4.3 Measuring and test equipment used for this procedure shall contain a valid calibration label in accordance with RHIC-MAG-Q-1000, where applicable.

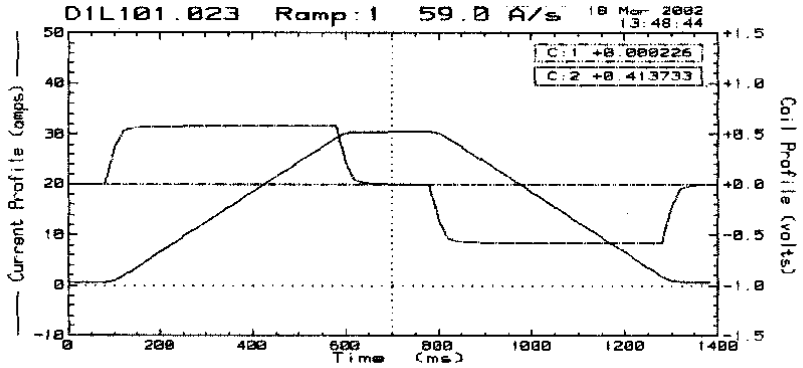
5 Preparation for Delivery:

N/A

Figures on following pages are reference plots of warm and cold results.



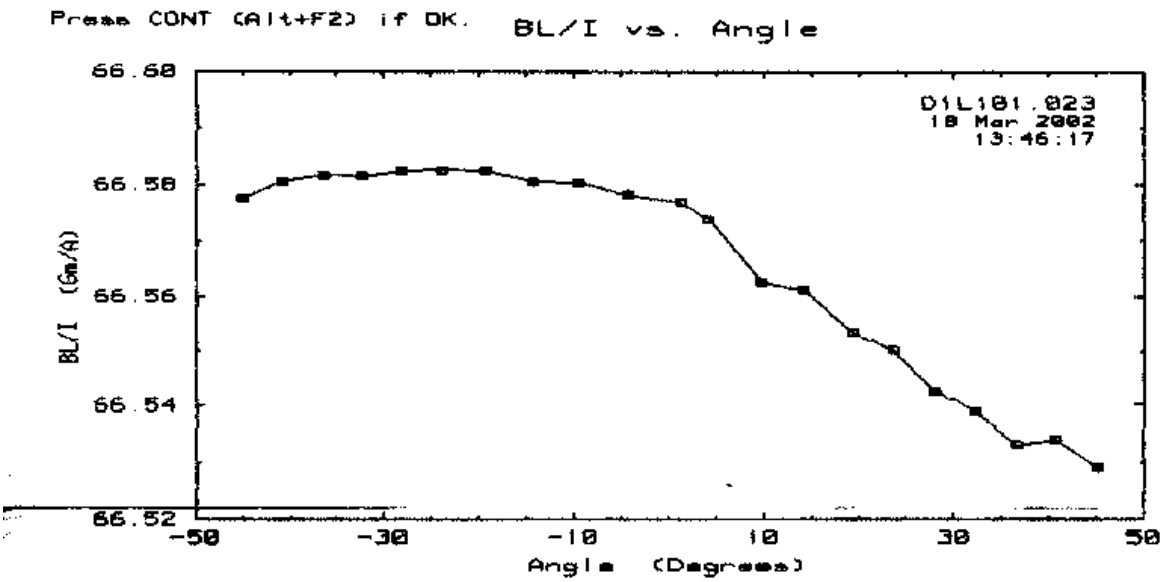

```
     13:34:14  Ramp: 59.0 +0.59584   30.44798    0.198739  66.574449
     13:34:50  Ramp: 59.0 +0.59562   30.44803    0.198762  66.581584
     13:34:58  Ramp: 59.0 +0.59590   30.44814    0.198745  66.576396
     13:35:01  Ramp: 59.0 +0.59634   30.44851    0.198743  66.575637
     13:35:05  Ramp: 59.0 +0.59590   30.44812    0.198750  66.577887
     13:35:09  Ramp: 59.0 +0.59643   30.45000    0.198761  66.578668
     13:35:13  Ramp: 59.0 +0.59605   30.44840    0.198752  66.578269
     13:35:16  Ramp: 59.0 +0.59635   30.44791    0.198743  66.577001
     13:35:20  Ramp: 59.0 +0.59592   30.44833    0.198751  66.578028
     13:35:24  Ramp: 59.0 +0.59598   30.44813    0.198741  66.575009
     13:35:28  Ramp: 59.0 +0.59584   30.44837    0.198743  66.574977
     13:35:31  Ramp: 59.0 +0.59575   30.44789    0.198736  66.573388
     13:35:35  Ramp: 59.0 +0.59564   30.44803    0.198737  66.573275
     13:35:39  Ramp: 59.0 +0.59650   30.44807    0.198746  66.578109
     13:35:42  Ramp: 59.0 +0.59621   30.44830    0.198754  66.579445
     13:35:46  Ramp: 59.0 +0.59611   30.44887    0.198753  66.577762
     13:35:50  Ramp: 59.0 +0.59591   30.44865    0.198752  66.577379
     13:35:54  Ramp: 59.0 +0.59591   30.44849    0.198758  66.579965
     13:35:57  Ramp: 59.0 +0.59613   30.44866    0.198744  66.575312
     13:36:01  Ramp: 59.0 +0.59633   30.44821    0.198749  66.578474
  1  13:36:01  Ramp: 59.0 +0.59603   30.44836    0.198748  66.577051 (4533)2152
C1 -0.2923554 C2 +0.2926535 √(C1²+C2²) 0.4136638 |C1|-|C2| -0.0003

     13:36:12  Ramp: 59.0 +0.59547   30.44751    0.198749  66.578012
     13:36:16  Ramp: 59.0 +0.59616   30.44789    0.198744  66.577081
     13:36:19  Ramp: 59.0 +0.59592   30.44765    0.198745  66.577321
     13:36:23  Ramp: 59.0 +0.59571   30.44839    0.198744  66.574874
     13:36:27  Ramp: 59.0 +0.59603   30.44823    0.198738  66.573862
     13:36:30  Ramp: 59.0 +0.59626   30.44795    0.198739  66.575346
     13:36:34  Ramp: 59.0 +0.59600   30.44736    0.198738  66.575735
     13:36:38  Ramp: 59.0 +0.59641   30.44830    0.198750  66.578796
     13:36:42  Ramp: 59.0 +0.59628   30.44740    0.198741  66.577236
     13:36:45  Ramp: 59.0 +0.59592   30.44786    0.198750  66.578598
     13:36:49  Ramp: 59.0 +0.59560   30.44826    0.198748  66.576215
     13:36:53  Ramp: 59.0 +0.59562   30.44793    0.198755  66.579319
     13:36:57  Ramp: 59.0 +0.59612   30.44823    0.198756  66.580130
     13:37:00  Ramp: 59.0 +0.59617   30.45092    0.198774  66.580244
     13:37:04  Ramp: 59.0 +0.59618   30.44814    0.198743  66.576051
     13:37:08  Ramp: 59.0 +0.59586   30.44798    0.198744  66.576225
     13:37:11  Ramp: 59.0 +0.59588   30.44832    0.198745  66.575645
     13:37:15  Ramp: 59.0 +0.59651   30.44957    0.198751  66.576396
     13:37:19  Ramp: 59.0 +0.59576   30.44816    0.198741  66.574432
     13:37:23  Ramp: 59.0 +0.59608   30.44768    0.198735  66.574378
  2  13:37:23  Ramp: 59.0 +0.59600   30.44819    0.198746  66.576795 (3449)1848
C1 -0.2923457 C2 +0.2926583 √(C1²+C2²) 0.4136604 |C1|-|C2| -0.0003

     13:48:28  Ramp: 59.0 +0.59449   30.44885    0.198766  66.578676
```




```
     13:48:44  Ramp: 59.0 +0.59416   30.44994    0.198781  66.580539
     13:49:20  Ramp: 59.0 +0.59374   30.45041    0.198783  66.578950
     13:49:24  Ramp: 59.0 +0.59499   30.44938    0.198759  66.575984
     13:49:28  Ramp: 59.0 +0.59513   30.45013    0.198764  66.576473
     13:49:32  Ramp: 59.0 +0.59496   30.44992    0.198763  66.576305
  1  13:49:32  Ramp: 59.0 +0.59460   30.44996    0.198770  66.577650 (2888)1789
C1 +0.0002296 C2 +0.4137096 √(C1²+C2²) 0.4137096 |C1|-|C2| -0.4135

     13:51:00  Ramp: 59.0 +0.59438   30.44837    0.198773  66.581670
     13:51:04  Ramp: 59.0 +0.59498   30.44816    0.198766  66.581148
     13:51:08  Ramp: 59.0 +0.59483   30.44914    0.198773  66.580969
     13:51:11  Ramp: 59.0 +0.59479   30.44871    0.198763  66.578430
     13:51:15  Ramp: 59.0 +0.59435   30.44874    0.198773  66.580844
  2  13:51:15  Ramp: 59.0 +0.59467   30.44862    0.198769  66.580612 (2182)1127
C1 -0.0295966 C2 +0.4126485 √(C1²+C2²) 0.4137086 |C1|-|C2| -0.3831

     13:54:37  Ramp: 59.0 +0.59385   30.44780    0.198766  66.579390
     13:54:41  Ramp: 59.0 +0.59479   30.44907    0.198783  66.584410
     13:54:44  Ramp: 59.0 +0.59525   30.44876    0.198768  66.581223
     13:54:48  Ramp: 59.0 +0.59442   30.44951    0.198778  66.580924
     13:54:52  Ramp: 59.0 +0.59498   30.44900    0.198777  66.582888
  3  13:54:52  Ramp: 59.0 +0.59466   30.44883    0.198774  66.581767 (2643)1726
C1 -0.0619801 C2 +0.4090496 √(C1²+C2²) 0.4137187 |C1|-|C2| -0.3471

     13:55:48  Ramp: 59.0 +0.59427   30.44855    0.198777  66.582475
     13:55:51  Ramp: 59.0 +0.59501   30.44933    0.198777  66.582205
     13:55:55  Ramp: 59.0 +0.59501   30.44933    0.198765  66.578294
     13:55:59  Ramp: 59.0 +0.59494   30.44878    0.198772  66.581578
     13:56:03  Ramp: 59.0 +0.59439   30.44939    0.198785  66.583600
  4  13:56:03  Ramp: 59.0 +0.59473   30.44908    0.198775  66.581630 (3336)1792
C1 -0.0906561 C2 +0.4036657 √(C1²+C2²) 0.4137203 |C1|-|C2| -0.3130

     13:57:32  Ramp: 59.0 +0.59413   30.44883    0.198781  66.582839
     13:57:36  Ramp: 59.0 +0.59449   30.44894    0.198778  66.582284
     13:57:40  Ramp: 59.0 +0.59477   30.44840    0.198771  66.581974
     13:57:44  Ramp: 59.0 +0.59467   30.44880    0.198775  66.582204
     13:57:47  Ramp: 59.0 +0.59492   30.44853    0.198774  66.583049
  5  13:57:47  Ramp: 59.0 +0.59459   30.44870    0.198776  66.582470 ( 579) 406
C1 -0.1199822 C2 +0.3959423 √(C1²+C2²) 0.4137221 |C1|-|C2| -0.2760

     13:59:56  Ramp: 59.0 +0.59461   30.44840    0.198781  66.584812
     13:59:59  Ramp: 59.0 +0.59456   30.44862    0.198775  66.582374
     14:00:03  Ramp: 59.0 +0.59393   30.44835    0.198773  66.580590
     14:00:07  Ramp: 59.0 +0.59441   30.44838    0.198782  66.584777
     14:00:10  Ramp: 59.0 +0.59448   30.44910    0.198774  66.580556
  6  14:00:10  Ramp: 59.0 +0.59440   30.44857    0.198777  66.582622 (2190)1892
C1 -0.1491731 C2 +0.3858950 √(C1²+C2²) 0.4137241 |C1|-|C2| -0.2367
```

```
     14:01:50  Ramp: 59.0 +0.59369   30.44858   0.198787  66.584429
     14:01:54  Ramp: 59.0 +0.59394   30.44761   0.198775  66.583271
     14:01:58  Ramp: 59.0 +0.59429   30.45117   0.198804  66.585790
     14:02:01  Ramp: 59.0 +0.59433   30.44845   0.198768  66.579679
     14:02:05  Ramp: 59.0 +0.59410   30.44836   0.198767  66.579084
  7  14:02:05  Ramp: 59.0 +0.59407   30.44883   0.198780  66.582451 (3367)2637
C1 -0.1793387 C2 +0.3728419 √(C1²+C2²) 0.4137312 |C1|-|C2| -0.1935

     14:04:17  Ramp: 59.0 +0.59341   30.44774   0.198771  66.580358
     14:04:20  Ramp: 59.0 +0.59393   30.44851   0.198777  66.581621
     14:04:24  Ramp: 59.0 +0.59438   30.44843   0.198769  66.580238
     14:04:28  Ramp: 59.0 +0.59371   30.44889   0.198776  66.580165
     14:04:32  Ramp: 59.0 +0.59394   30.44797   0.198770  66.580571
  8  14:04:32  Ramp: 59.0 +0.59388   30.44831   0.198773  66.580590 (1030) 533
C1 -0.2104770 C2 +0.3561735 √(C1²+C2²) 0.4137151 |C1|-|C2| -0.1457

     14:06:16  Ramp: 59.0 +0.59335   30.44768   0.198779  66.582967
     14:06:20  Ramp: 59.0 +0.59398   30.44893   0.198784  66.583428
     14:06:23  Ramp: 59.0 +0.59449   30.44812   0.198768  66.580850
     14:06:27  Ramp: 59.0 +0.59379   30.44819   0.198764  66.577654
     14:06:31  Ramp: 59.0 +0.59414   30.44853   0.198761  66.576848
  9  14:06:31  Ramp: 59.0 +0.59395   30.44829   0.198771  66.580350 (3501)2687
C1 -0.2405610 C2 +0.3365831 √(C1²+C2²) 0.4137122 |C1|-|C2| -0.0960

     14:07:23  Ramp: 59.0 +0.59269   30.44848   0.198763  66.574247
     14:07:26  Ramp: 59.0 +0.59369   30.44781   0.198766  66.579072
     14:07:30  Ramp: 59.0 +0.59375   30.44813   0.198759  66.576029
     14:07:34  Ramp: 59.0 +0.59363   30.44786   0.198770  66.580051
     14:07:37  Ramp: 59.0 +0.59372   30.44821   0.198776  66.581685
 10  14:07:37  Ramp: 59.0 +0.59350   30.44810   0.198767  66.578217 (3969)2708
C1 -0.2698075 C2 +0.3136140 √(C1²+C2²) 0.4137026 |C1|-|C2| -0.0438

     14:09:30  Ramp: 59.0 +0.59327   30.44869   0.198756  66.572672
     14:09:34  Ramp: 59.0 +0.59366   30.44804   0.198765  66.578224
     14:09:37  Ramp: 59.0 +0.59344   30.44790   0.198766  66.578195
     14:09:41  Ramp: 59.0 +0.59397   30.44825   0.198766  66.578651
     14:09:45  Ramp: 59.0 +0.59359   30.44781   0.198760  66.576710
 11  14:09:45  Ramp: 59.0 +0.59358   30.44814   0.198762  66.576891 (4218)2209
C1 -0.2989882 C2 +0.2859170 √(C1²+C2²) 0.4136937 |C1|-|C2| +0.0131

     14:10:19  Ramp: 59.0 +0.59277   30.44815   0.198754  66.572104
     14:10:23  Ramp: 59.0 +0.59361   30.44848   0.198758  66.574880
     14:10:27  Ramp: 59.0 +0.59409   30.44879   0.198761  66.575968
     14:10:30  Ramp: 59.0 +0.59386   30.44810   0.198753  66.574452
     14:10:34  Ramp: 59.0 +0.59372   30.44834   0.198749  66.572228
 12  14:10:34  Ramp: 59.0 +0.59361   30.44837   0.198755  66.573926 (2042)1520
C1 -0.3130849 C2 +0.2703840 √(C1²+C2²) 0.4136782 |C1|-|C2| +0.0427

     14:12:11  Ramp: 59.0 +0.59210   30.44768   0.198726  66.562275
     14:12:14  Ramp: 59.0 +0.59297   30.44788   0.198722  66.562715
     14:12:18  Ramp: 59.0 +0.59351   30.44859   0.198729  66.564692
     14:12:22  Ramp: 59.0 +0.59370   30.44860   0.198721  66.562282
     14:12:25  Ramp: 59.0 +0.59323   30.44832   0.198717  66.560455
 13  14:12:25  Ramp: 59.0 +0.59310   30.44821   0.198723  66.562484 (2208)1351
C1 -0.3378614 C2 +0.2385885 √(C1²+C2²) 0.4136119 |C1|-|C2| +0.0993

     14:13:18  Ramp: 59.0 +0.59224   30.44713   0.198717  66.561095
     14:13:22  Ramp: 59.0 +0.59347   30.44815   0.198717  66.561374
     14:13:26  Ramp: 59.0 +0.59336   30.44939   0.198721  66.559895
     14:13:29  Ramp: 59.0 +0.59337   30.44778   0.198715  66.561476
     14:13:33  Ramp: 59.0 +0.59326   30.44822   0.198720  66.561717
 14  14:13:33  Ramp: 59.0 +0.59314   30.44813   0.198718  66.561111 (1217) 640
C1 -0.3554677 C2 +0.2114454 √(C1²+C2²) 0.4136018 |C1|-|C2| +0.1440
```

```
     14:15:03  Ramp: 59.0 +0.59251   30.44703   0.198685  66.550973
     14:15:07  Ramp: 59.0 +0.59291   30.44805   0.198699  66.554319
     14:15:11  Ramp: 59.0 +0.59277   30.44756   0.198696  66.554195
     14:15:14  Ramp: 59.0 +0.59291   30.44812   0.198697  66.553637
     14:15:18  Ramp: 59.0 +0.59313   30.44803   0.198700  66.555218
 15  14:15:18  Ramp: 59.0 +0.59285   30.44776   0.198695  66.553669 (2696)1440
C1 -0.3727745 C2 +0.1790708 √(C1²+C2²) 0.4135543 |C1|-|C2| +0.1937

     14:16:47  Ramp: 59.0 +0.59184   30.44758   0.198689  66.549808
     14:16:50  Ramp: 59.0 +0.59295   30.44775   0.198687  66.551056
     14:16:54  Ramp: 59.0 +0.59229   30.44734   0.198680  66.548166
     14:16:58  Ramp: 59.0 +0.59285   30.44807   0.198686  66.549794
     14:17:02  Ramp: 59.0 +0.59283   30.44842   0.198696  66.552227
 16  14:17:02  Ramp: 59.0 +0.59255   30.44783   0.198688  66.550210 (2043)1364
C1 -0.3849421 C2 +0.1511067 √(C1²+C2²) 0.4135380 |C1|-|C2| +0.2338

     14:18:37  Ramp: 59.0 +0.59225   30.44802   0.198682  66.547183
     14:18:41  Ramp: 59.0 +0.59251   30.44773   0.198661  66.541394
     14:18:45  Ramp: 59.0 +0.59293   30.44783   0.198661  66.542160
     14:18:48  Ramp: 59.0 +0.59195   30.44734   0.198661  66.541247
     14:18:52  Ramp: 59.0 +0.59225   30.44749   0.198664  66.542581
 17  14:18:52  Ramp: 59.0 +0.59238   30.44768   0.198666  66.542913 (4270)2191
C1 -0.3953996 C2 +0.1209777 √(C1²+C2²) 0.4134930 |C1|-|C2| +0.2744

     14:21:00  Ramp: 59.0 +0.59180   30.44677   0.198660  66.541717
     14:21:04  Ramp: 59.0 +0.59213   30.44728   0.198652  66.538744
     14:21:08  Ramp: 59.0 +0.59223   30.44716   0.198654  66.539837
     14:21:12  Ramp: 59.0 +0.59253   30.44669   0.198640  66.536895
     14:21:15  Ramp: 59.0 +0.59226   30.44679   0.198645  66.537676
 18  14:21:15  Ramp: 59.0 +0.59219   30.44694   0.198650  66.538974 (2743)1693
C1 -0.4031663 C2 +0.0916885 √(C1²+C2²) 0.4134608 |C1|-|C2| +0.3115

     14:22:10  Ramp: 59.0 +0.59163   30.44735   0.198638  66.532758
     14:22:14  Ramp: 59.0 +0.59201   30.44743   0.198636  66.532647
     14:22:18  Ramp: 59.0 +0.59204   30.44784   0.198640  66.533252
     14:22:21  Ramp: 59.0 +0.59234   30.44772   0.198640  66.534048
     14:22:25  Ramp: 59.0 +0.59222   30.44744   0.198634  66.532455
 19  14:22:25  Ramp: 59.0 +0.59205   30.44755   0.198638  66.533032 (1016) 572
C1 -0.4089898 C2 +0.0604592 √(C1²+C2²) 0.4134343 |C1|-|C2| +0.3485

     14:23:48  Ramp: 59.0 +0.59176   30.44680   0.198640  66.534683
     14:23:52  Ramp: 59.0 +0.59180   30.44771   0.198632  66.530238
     14:23:56  Ramp: 59.0 +0.59220   30.44707   0.198634  66.533282
     14:24:00  Ramp: 59.0 +0.59225   30.44697   0.198639  66.535184
     14:24:03  Ramp: 59.0 +0.59215   30.44645   0.198638  66.535914
 20  14:24:03  Ramp: 59.0 +0.59203   30.44700   0.198637  66.533860 (3622)2004
C1 -0.4122846 C2 +0.0307803 √(C1²+C2²) 0.4134320 |C1|-|C2| +0.3815

     14:26:24  Ramp: 59.0 +0.59144   30.44739   0.198621  66.526431
     14:26:28  Ramp: 59.0 +0.59198   30.44715   0.198627  66.530273
     14:26:32  Ramp: 59.0 +0.59171   30.44612   0.198625  66.531231
     14:26:36  Ramp: 59.0 +0.59165   30.44689   0.198627  66.529862
     14:26:39  Ramp: 59.0 +0.59176   30.44642   0.198615  66.527235
 21  14:26:39  Ramp: 59.0 +0.59171   30.44679   0.198623  66.529006 (2575)1847
C1 -0.4134024 C2 -0.0009673 √(C1²+C2²) 0.4134035 |C1|-|C2| +0.4124
```



D1L101.023 18 Mar 2002 13:46:17

1	+0.0002296	+0.4137096	-45.0	66.577650
2	-0.0295966	+0.4126485	-40.9	66.580612
3	-0.0619801	+0.4090496	-36.4	66.581767
4	-0.0906561	+0.4036657	-32.3	66.581630
5	-0.1199822	+0.3959423	-28.1	66.582470
6	-0.1491731	+0.3850950	-23.9	66.582622
7	-0.1793387	+0.3728419	-19.3	66.582451
8	-0.2104770	+0.3561735	-14.4	66.580590
9	-0.2405610	+0.3365031	-9.4	66.580350
10	-0.2698075	+0.3136140	-4.3	66.578217
11	-0.2989882	+0.2859170	1.3	66.576891
12	-0.3130849	+0.2703840	4.2	66.573926
13	-0.3378614	+0.2385885	9.8	66.562484
14	-0.3554677	+0.2114454	14.3	66.561111
15	-0.3727745	+0.1790708	19.3	66.553669
16	-0.3849421	+0.1511067	23.6	66.550210
17	-0.3953996	+0.1209777	28.0	66.542913
18	-0.4031663	+0.0916085	32.2	66.538974
19	-0.4089898	+0.0604592	36.6	66.533032
20	-0.4122846	+0.0307803	40.7	66.533860
21	-0.4134024	-0.0009673	45.1	66.529006

18 Mar 2002 14:28:01